Stephenson, B.M. 2005. Variability in the breeding ecology of Australasian gannets, *Morus serrator*, at Cape Kidnappers, New Zealand. *PhD thesis*. Massey University, New Zealand.

Thesis abstract

The Australasian gannet, *Morus serrator*, a member of the Family Sulidae, primarily inhabits New Zealand and Australian coastal waters. It is considered to be closely related to the Atlantic gannet, *Morus bassana*, in the North Atlantic, and Cape gannet, *Morus capensis*, in South African waters, with which it shares similar ecological niches.

Although often described as relatively well studied, much of our current knowledge of Australasian gannets has been derived from anecdotal observations, and irregular visits to breeding colonies. Few studies have derived information from continuous observations of known individuals over consecutive breeding seasons. Conversely, studies of Atlantic gannets, in particular, have been conducted on a far more rigorous basis. Thus, parallels drawn between the three species, and particularly Atlantic and Australasian gannets, may or may not be accurate.

This study is the first to document three complete and consecutive breeding seasons (1999-00, 2000-01, and 2001-02), using marked nests at the Plateau colony, Cape Kidnappers, New Zealand. Birds were individually marked and I investigated their breeding ecology, and in particular the annual variability in success and other breeding variables. Contrasting with previous studies, I found that the onset of egg laying differed little between years, and although laying was less synchronous in one season, it was highly synchronous in the other two seasons. This is similar to the Atlantic gannet in which the onset of laying is similar year to year, and laying is also highly synchronised. At least for the Australasian gannet, the timing of egg laying does not appear to be linked to sea surface temperature near the colony. However, both species appear to time egg laying to allow chick rearing to coincide with a predictably timed peak in prey availability. Further in depth study is required to confirm this for the Australasian gannet breeding in New Zealand. The use of back-dating to estimate the onset of egg laying from hatching dates and chick ages was also tested and found to provide a useful estimate.

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Although previous studies of Australasian gannets have suggested highly variable breeding success, with almost complete breeding failures in some years, this study is the first to document this, and explore possible reasons. Previous studies have suggested human disturbance at breeding colonies as being the cause, with little evidence provided. However, I found in 1999-00, there was considerable egg and chick losses as a result of environmental conditions causing adult and chick starvation and desertion of eggs and young chicks, and productivity was only 9%. A similar pattern, although less severe, occurred in the following season, but conditions improved during the chick rearing stage resulting in 55% productivity. In 2001-02, environmental conditions were stable, resulting in high hatching success, however, an unseasonal storm resulted in considerable chick mortality, and productivity was again low at only 13%. Thus, productivity during the three seasons studied varied markedly, being very low in two of the three seasons as a consequence of environmental conditions, with no evidence of human disturbance. This is the first study which has linked the environment to variable breeding success in this species, and its findings contrast considerably with the invariably high breeding success of the Atlantic gannet. Retrospective analysis of previous Australasian gannet studies suggests this natural link between the environment and breeding success has been apparent, but not recognised, since the 1940s. Links between specific environmental factors and breeding failures are yet to be determined.

I established that calculated egg volume is a good predictor of fresh egg mass, allowing analysis of eggs through the use of linear measurements, when fresh egg mass is not known. For all seasons combined mean egg volume was 89.2 mm^3, whilst a mean incubation period of 45 days is similar to other Australasian gannet studies. Changes in specific gravity during egg development did not allow accurate determination of egg laying dates, with 12.7% of fresh egg mass being lost during development. Eggs laid both within and between seasons by individual females were highly correlated in all measures (length, width, shape, and volume). These egg measures generally showed a negative correlation with laying date, at least in the last two breeding seasons.

Egg volume was positively correlated with chick mass at hatching, although chick growth rates did not seem correlated with egg volume. However, in 2000-01, chicks that survived to fledging were significantly heavier on day-one, despite hatching from similar volume eggs. For chicks that fledged successfully, those that hatched later in the season increased in mass more slowly than chicks that hatched early. However, the reverse trend was found for wing length, possibly as a consequence of wing development being more important than mass increase.

Linked to the breeding failures in 1999-00, were low nest attendance rates by adults and the lowest recorded body mass for adult Australasian gannets in this or previous studies. Similarly, first egg volumes in this first season were significantly lower, and fewer lost eggs were replaced. Chick growth rates also varied between breeding seasons. Early development of chicks (0-11 days) was slower in 1999-00 than in the other two seasons (slower even than chicks that did not fledge in the other seasons). Growth rates of older chicks (20+ days) that survived to fledge, however, were actually greatest in that season. This suggests that older or more experienced adults, who were better able to provision chicks through poor foraging conditions, were then able to raise faster developing chicks once conditions improved.

The evidence presented in this thesis demonstrates that the 1999-00 breeding season was a difficult one for breeding Australasian gannets at Cape Kidnappers. Furthermore, information derived from this three season study, along with analysis of historical studies, suggests that the Australasian gannet differs markedly to the Atlantic gannet in many respects. Most notable is the occurrence of pronounced breeding failures in some years, apparently influenced by environmental conditions. This seems to be a consequence of a more variable environment, involving variability in weather, oceanographic conditions, and prey availability and abundance.